

REMARKS

In the last Office Action, the Examiner objected to the disclosure as containing an informality. Claims 10, 13-15 and 18 were objected to because several parameters recited in the claims are not defined. Claims 1, 3, 4, 11 and 17 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 3, 4, 11, 21 and 27 of copending Application No. 10/875,114 ("the '114 application"). Claims 22-23 have been allowed by the Examiner. Claims 2, 5-10, 12-16 and 18-21 were objected to as being dependent upon a rejected base claim, but indicated to be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Additional art was cited of interest.

Applicant and applicant's counsel note with appreciation the indication of allowable subject matter concerning claims 2, 5-10, 12-16, 18-21 and 22-23 (now claims 25-26). However, for the reasons noted below, applicant respectfully submits that amended claims 1, 3, 4, 11 and 17 and new claims 24 and 27-37 also patentably distinguish from the prior art of record.

In accordance with the present response, the specification has been suitably revised to correct minor informalities, update the cross-reference information added by the December 30, 2003 preliminary amendment, and to bring into

better conformance with U.S. practice. Independent claims 1, 4, 11 and 17 have been amended to further patentably distinguish from the prior art of record. Original claims 1-21 have also been amended in formal respects to improve the wording, correct instances of indefiniteness, and bring them into better conformance with U.S. practice. Allowed claims 22-23 have been rewritten as new claims 25-26 to correct informalities, improve the wording, and bring them into better conformance with U.S. practice. New claims 27-37 have been added to provide a fuller scope of coverage. The title of the invention has been changed to "QUARTZ CRYSTAL RESONATOR, UNIT HAVING RESONATOR, OSCILLATOR HAVING UNIT, ELECTRONIC APPARATUS HAVING OSCILLATOR, AND METHOD FOR MANUFACTURING ELECTRONIC APPARATUS" to more clearly reflect the invention to which the amended and new claims are directed. A new, more descriptive abstract has been substituted for the original abstract.

In view of the foregoing, applicant respectfully submits that the objections to the specification and claims have been overcome and should be withdrawn.

Applicant requests reconsideration of his application in light of the following discussion.

Brief Summary of the Invention

The present invention is directed to a quartz crystal resonator, a unit having the resonator, and oscillator

having the unit, and electronic apparatus having the oscillator, and a method for manufacturing the electronic apparatus.

Quartz crystal tuning fork resonators which vibrate in a flexural mode are widely used as a time standard in communication equipment such as wristwatches, cellular phones, and pagers. Due to miniaturization and light weight requirements for these products, such quartz crystal tuning fork resonators must be small with a low series resistance and a high quality factor. However, it has not been possible to miniaturize the conventional quartz crystal tuning fork resonators while achieving a small series resistance and a high quality factor. This is due to the fact that the conventional quartz crystal tuning fork resonators have a small electro-mechanical transformation efficiency which generates a small electric field.

The present invention overcomes the drawbacks of the conventional art. Figs. 4-6 show an embodiment of a quartz crystal resonator according to the present invention embodied in claims 1-3. The quartz crystal resonator comprises a quartz crystal tuning fork resonator 10 capable of vibrating in a flexural mode of an inverse phase. The quartz crystal tuning fork resonator 10 comprises a quartz crystal tuning fork base 40 and first and second quartz crystal tuning fork tines 20, 26 connected to the quartz crystal tuning fork base

40. Each of the first and second quartz crystal tuning fork tines 20, 26 has a first main surface and a second main surface opposite the first main surface and a groove 21, 27 having stepped portions formed in at least one of the first and second main surfaces of each of the first and second quartz crystal tuning fork tines 20, 26.

According to the present invention, an electrode (e.g., 23, 24) is disposed in the groove formed in at least one of the first and second main surfaces of each of the first and second quartz crystal tuning fork tines 20, 26 so that a merit value M_1 of a fundamental mode of vibration of the quartz crystal tuning fork resonator 10 is greater than a merit value M_2 of a second overtone mode of vibration thereof, the merit values M_1 and M_2 being defined by the ratios Q_1/r_1 and Q_2/r_2 , respectively, where Q_1 and Q_2 represent a quality factor of the fundamental mode of vibration and the second overtone mode of vibration, respectively, of the quartz crystal tuning fork resonator 10 and r_1 and r_2 represent a capacitance ratio of the fundamental mode of vibration and the second overtone mode of vibration, respectively, of the quartz crystal tuning fork resonator 10. A piezoelectric constant e_{12} of the the quartz crystal tuning fork resonator 10 is within a range of 0.095 C/m^2 to 0.19 C/m^2 in the absolute value.

In other aspects, the present invention provides a quartz crystal unit having the quartz crystal resonator (claims 4-10, 24), a quartz crystal oscillator having the quartz crystal unit (claims 11-16), an electronic apparatus having the quartz crystal oscillator (claims 17-21), and a method for manufacturing the electronic apparatus (claims 25-37).

By the foregoing construction, the electro-mechanical transformation efficiency of the quartz crystal tuning fork resonator according to the present invention becomes large, thereby enabling the quartz crystal tuning fork resonator to be miniaturized while achieving a low series resistance and a high quality factor.

Travresal of Prior Art Rejection

Claims 1, 3, 4, 11 and 17 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 3, 4, 11, 21 and 27, respectively, of the '114 application. Applicant respectfully traverses the Examiner's double patenting rejection based on the '114 application.

Applicant respectfully submits that amended application claims 1, 3, 4, 11 and 17 recite subject matter which is not recited by, nor an obvious variation of, claims 3, 4, 11, 21 and 27 of the '114 application.

In other aspects, the present invention provides a quartz crystal unit having the quartz crystal resonator (claims 4-10, 24), a quartz crystal oscillator having the quartz crystal unit (claims 11-16), an electronic apparatus having the quartz crystal oscillator (claims 17-21), and a method for manufacturing the electronic apparatus (claims 25-37).

By the foregoing construction, the electro-mechanical transformation efficiency of the quartz crystal tuning fork resonator according to the present invention becomes large, thereby enabling the quartz crystal tuning fork resonator to be miniaturized while achieving a low series resistance and a high quality factor.

Traversal of Prior Art Rejection

Claims 1, 3, 4, 11 and 17 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 3, 4, 11, 21 and 27, respectively, of the '114 application. Applicant respectfully traverses the Examiner's double patenting rejection based on the '114 application.

Applicant respectfully submits that amended application claims 1, 3, 4, 11 and 17 recite subject matter which is not recited by, nor an obvious variation of, claims 3, 4, 11, 21 and 27 of the '114 application.

Each of independent claims 1, 4, 11 and 17 has been amended to patentably distinguish from claims 3, 4, 11, 21 and 27 of the '114 application by reciting an electrode disposed in the groove formed in at least one of the first and second main surfaces of each of the first and second quartz crystal tuning fork tines so that a merit value M_1 of a fundamental mode of vibration of the quartz crystal tuning fork resonator is greater than a merit value M_2 of a second overtone mode of vibration thereof, the merit values M_1 and M_2 being defined by the ratios Q_1/r_1 and Q_2/r_2 , respectively, where Q_1 and Q_2 represent a quality factor of the fundamental mode of vibration and the second overtone mode of vibration, respectively, of the quartz crystal tuning fork resonator and r_1 and r_2 represent a capacitance ratio of the fundamental mode of vibration and the second overtone mode of vibration, respectively, of the quartz crystal tuning fork resonator.

The foregoing specific structure and parameter values recited in each of amended independent claims 1, 4, 11 and 17 of the present application are absent from claims 3, 4, 11, 21 and 27 of the '114 application. Furthermore, there is nothing in claims of the '114 application that would have motivated one of ordinary skill in the art to modify the invention claimed therein to replicate the invention recited in amended independent claims 1, 4, 11 and 17 of the present application.

Claim 3 depends on and contains all of the limitations of amended independent claim 1 and, therefore, distinguishes from the claims of the '114 application at least in the same manner as amended independent claim 1.

In view of the foregoing, applicants respectfully submit that the rejection of claims 1, 4, 11 and 17 on the basis of the judicially created doctrine of obviousness-type double patenting over claims 3, 4, 11, 21 and 27 of the '114 application has been overcome and should be withdrawn.

Applicants respectfully submit that newly added claims 24 and 27-37 also patentably distinguish from the prior art of record.

New claim 24 depends on and contains all of the limitations of amended independent claim 4 and, therefore, distinguishes from the prior art of record at least in the same manner as independent claim 4.

New claims 27-37 depend on and contain all of the limitations of allowed independent claim 25 and, therefore, are also allowable.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for allowance. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

ADAMS & WILKS
Attorneys for Applicant

By: 
Bruce L. Adams

Reg. No. 25,386

17 Battery Place
Suite 1231
New York, NY 10004
(212) 809-3700

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Debra Buonincontri

Name

Debra Buonincontri

Signature

August 16, 2005

Date